NOISE EXPOSURE OF NAVAL COMMUNICATION STATION RADIO OPERATORS: A FIELD STUDY

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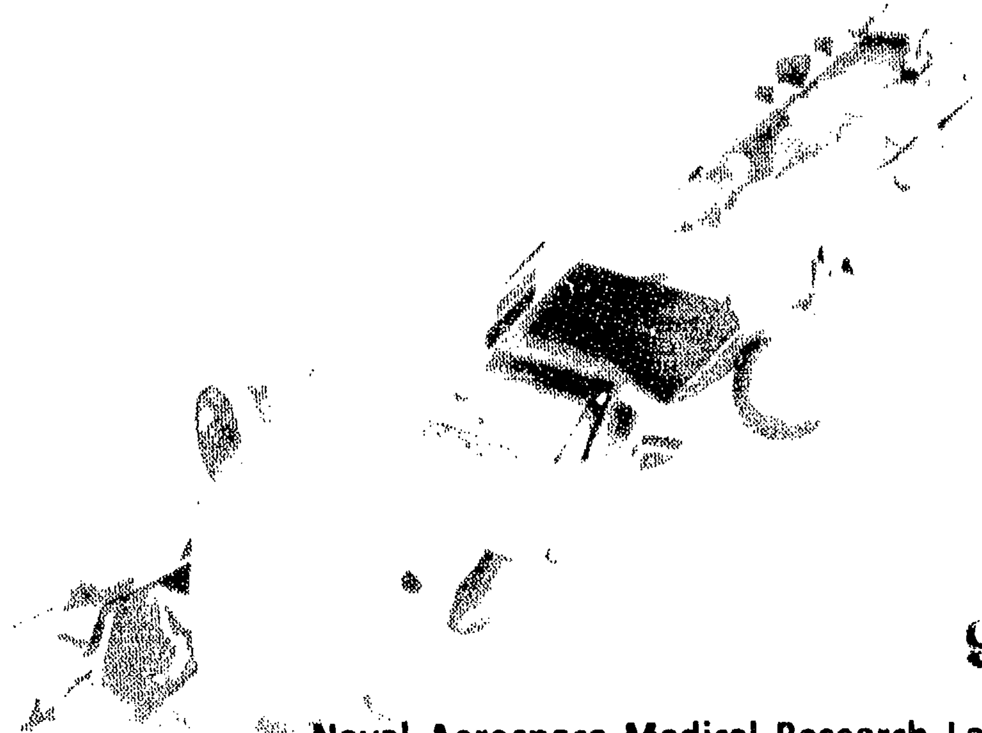

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In 1979, the Naval Security Group Headquarters requested the Acoustical Sciences Division, Naval Aerospace Medical Research Laboratory (NAMRL), to determine the extent to which radio headsets being used at naval communication stations posed a potential damage risk to hearing. The purpose of this technical memorandum is to document data obtained during a site visit at the naval communication station located near Homestead Air Force Base, Florida. The data-gathering visit followed a preliminary information-gathering visit to the naval communication station known as Northwest. Conclusions of the data-gathering field study were as follows: (1) Manual Morse code operators face a significant probability of exposure to hazardous noise levels; (2) the type of headset used is not a primary factor in the noise exposure of manual Morse operators; (3) the new automated signal acquisition system will probably increase operator noise exposure; and (4) ambient noise levels do not constitute a significant source of noise exposure for manual Morse code operators. Keywords.

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INTRODUCTION

In 1979, the Naval Security Group Headquarters requested the Acoustical Sciences Division, Naval Aerospace Medical Research Laboratory (NAMRL), to determine the extent to which radio headsets being used at naval communication stations posed a potential damage risk to hearing. The purpose of this technical memorandum is to document data obtained during a site visit at the naval communication station located near Homestead Air Force Base, Florida. The data-gathering visit followed a preliminary information-gathering visit to the naval communication station known as Northwest.

SUMMARY OF DATA GATHERING AT NAVAL COMMUNICATION STATION NEAR HOMESTEAD AIR FORCE BASE (MAY 7-10, 1979)

The Homestead site had a much larger number of manual Morse operators than did Northwest. In contrast to Northwest where much activity was observed, most positions at Homestead were set to predetermined frequencies so that the operator's task was primarily one of monitoring.

Homestead was on a three-shift system with approximate start/stop times being 0700 to 1600 (day), 1600 to 2400 (eve), and 2400 to 0700 (mid). Approximately every 3 weeks, individual operators got 3 days off, and operators routinely had less than 8 hours off between shifts when shifts overlapped.

Although the R-390 receiver had a limiter circuit and control, most operators did not use it. In a briefing at the Naval Technical Training Center, Corry Station, before the field trip, the investigators were told this would be the case. The use of the limiter is not taught in the manual Morse code training program at Corry Station, nor is its use stressed at Homestead.

Several types of headsets were in use at the test site. The most frequently used headset was the standard Bakelite Murdock, Type NT-49016A. The Telex Twinset was the second most frequently observed unit. This is a binaural insert-type headset whose transducer is located on the headband, and whose acoustic signal is then fed to the ear tips. Most operators did not wear the ear tips inserted into the ear canal, but a few operators were observed doing so. The least-used unit (observed on only two or three operators) was an inexpensive, light-weight, supra-aural, Japanese-built device.

In response to a Naval Security Group Command hearing conservation instruction, Homestead personnel had just received hearing tests before the data-gathering team arrived.

METHOD

SUBJECTS

Subjects for the dosimetry portion of the study were 33 manual Morse code operators. A sampling of 25 subjects, all of whom were in the CTR rate or MOS 26221, were given hearing tests.

EQUIPMENT

Varied types of instrumentation were employed in the study. The Metrosonic Model 301 Metrologger and Model 651 Metroreader were used in the noise dosimetry aspect of the survey. The 301 is a personal sound-level-monitoring device utilizing a quarter-inch remote ceramic microphone worn at the ear. It is a microprocessor-controlled device that stores noise-level information in either time-history or amplitude-distribution format. The unit has a dynamic range of 64 dB and a baseline of 60 or 70 dBA depending on the PROM selected. After the monitoring period is over, the stored digital information is transferred to the model 651 Metroreader, which produces a thermally printed copy of the findings.

Ambient noise measurements were obtained with a General Radio sound-level meter (Model 1933). Hearing tests were accomplished with a Grason-Stadler Model 1707 pure tone audiometer. Two unique transducers were evaluated in terms of their signal monitoring capability. One was the Radioear B70A bone conduction unit, and the other was a two-speaker shoulder-worn unit on loan from the Naval Ship Engineering Center (NAVSEC). Finally, an Altec Model 436B compressor or amplifier was tested as a means of reducing the acoustic output of the R-390. Volume compressors have been used for many years by broadcasting networks to automatically control peak signal levels without any audible changes in network attenuation or background noise. The compressor characteristics are usually adjusted for a relatively fast attack time (5-10 ms) and a slow release time (1-2 s).

PROCEDURE

Personal sound-level monitoring devices were placed on each of six subjects at the beginning of their watch. In all, three day watches, two mid watches, and two eve watches were monitored. Subjects were instructed not to remove their dosimeters during their watch and to wear them to chow, the restroom, et cetera. Overall compliance with the instructions was good, although one or two exceptions were noted. In one instance, a subject left his dosimeter at his operator position during breaks, but the effect of this noncompliance on the overall exposure information was probably minimal. The investigators removed the dosimeters at the end of each watch, and the data were then transferred to the 651 Metroreader and printed out at that time.

The Altec 436B compressor was connected to an operator position between the earphone jack and the headset. The compressor was adjusted to provide a "comfortable" listening level while providing an average of 10 dB of compression. Thus, when a signal was received, the gain was reduced by 10-15 dB, and without a signal, the gain automatically increased gradually to the preadjusted output level. To test this, several senior technicians (CTRs) were asked to listen to the signals and comment on what they heard.

Hearing Threshold Measurements (HTLs)

The HTLs (frequency range 1000-6000 Hz) of each of the 25 subjects were obtained in an office area where the announcement/music speaker was disconnected to reduce the ambient noise. Measurements of the ambient noise, obtained with a Grason-Stadler Model 1933 sound-level meter, indicated minimal levels that would not affect measurement in the frequency range tested.

Ambient Noise Measurements - Collection Room

During each of the seven work shifts surveyed, octave-band-level measurements were obtained at each end of the manual Morse code room.

Operator Trials with New Transducers

Ten operators volunteered to wear the Radioear B70A bone conduction unit. Each subject wore the unit for 10-15 min and was then asked for comments. The NAVSEC shoulder speakers were evaluated similarly but with only 2-3 subjects.

RESULTS AND DISCUSSION

EXPOSURE MONITORING

Table 1 summarizes the Metrologger findings. The most important information in the table is shown in the columns labeled LEQ and LOSHA (85). Of the four exposure values available from the Metrologger, these two measures are considered to be most applicable to the question at hand: Are manual Morse code operators exposed to hazardous noise levels in their operational setting?

The LEQ (equivalent level) measurement follows the "equal energy rule." Damage risk criteria based on the "equal energy rule" state that because the equivalent of up to 90 dBA exposure in an 8 h period is acceptable, for every 3 dB above 90, the exposure time would have to be reduced by a factor of two to be below a hazardous value.[1] For example, at a level of 93 dB, a 4-h exposure would be permissible without protection; at 96 dB, a 2-h exposure, et cetera. The LEQ calculation made by the Metrologger includes energy down to the baseline of the instrument (either 60 or 70 dB).

The LOSHA (85) is computed on the basis of a possible future level to be adopted by the Occupational Safety and Health Administration. These damage risk criteria state that the equivalent of up to 85 dBA exposure in an 8-h period is acceptable without hearing protection, and that for every 5 dB above 85, the exposure time would be reduced by a factor of two.[1] In this computation, no energy below 85 dB is included by the Metrologger.

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[1] Navy hearing damage risk criteria promulgated since 1979 are more stringent (1).

A review of the information in Table 1 indicates that 19 of 39 LEQ monitoring periods show levels of 90 dBA or greater. This means that 49% of the monitoring periods were potentially hazardous for the operators. Similar findings resulted when the LOSHA data were examined. Of the 24 LOSHA (85) monitoring periods, 12 (or 50%) exceeded the damage risk criterion of 85 dBA or greater. The number of operators wearing the standard Murdock unit and the Telex unit were divided about equally for both the LEQ and LOSHA (85) calculations. Therefore, the type of headset used by the operator is not felt to be a critical factor in the exposure.[2] Because maximum levels recorded sometimes reached 128 dBA and 50% of the operator positions posed an auditory hazard to the operators, we concluded that some means must be found to reduce acoustic levels available at the headsets.

The survey team concluded that personnel with exposure would increase after the installation of the new automated search system due to much shorter periods of "no signal." Because the operator will be receiving even more exposure to tonal signals than is now the case, the automated system must have some provision for automatic signal limiting at the operator's position.

Table 2 shows the noise-exposure distribution by workshift. The highest probability for over-exposure is during the eve watch, followed by the day and mid watches, respectively.

Three interim measures could be implemented to reduce operator noise exposure. The first involves the study of, and possible realignment of, work shifts. If possible, an individual should have as close to 16 h between work shifts as is practical. Second, local training in the proper use of the noise limiter on the R-390 should be instituted as soon as possible. Third, although no change in the transducers currently used at Homestead appears necessary, the insertion of the Telex ear tips into the ear canal should be prohibited.

AMBIENT NOISE

Ambient-noise measurements in the collection room were so similar over the seven measurements taken that data have been averaged for each of the two measurement positions (Table 3). The ambient-noise levels observed are not sufficiently high to be of concern as a significant source of exposure for the operators.

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[2] During monitoring periods 18 and 23, the operators wore the Telex with the headset tips seated in the ear canals. It is assumed that exposure levels in these cases were higher than the levels indicated in Table 1.

TABLE 1. Summary of Noise-exposure Data Obtained on Manual Morse Code Operators.

Monitoring Period	Work Shift[1]	Position Number	Earphone Type[2]	Sample Time (Hr 6 Min)	LEQ[3]	LOSHA (85)[4]	Maximum Level	Comments
1	D	4	B	2.26	90	83	115	
2	D	33	B	2.22	99	95	124	
3	D	2	T	2.19	81	71	105	
4	D	24	B	2.12	101	95	124	
5	D	4	B	2.31	81			Time history
6	D	1	T	2.27	82			Time history
7	D	10	T	8.00	83			Time history
8	D	3	B/T	8.00	86			Time history
9	D	7	T	8.12	98	92	123	B-3 h; T-5 h
10	D	?	?	8.12	102	97	128	
11	D	1	T	8.22	90	86	109	
12	D	?	?	8.14	86	75	117	
13	D	4	T	[illegible].03	95			Time history
14	D	24	B	6.04	101			Time history; 4 receivers; 2 phones
15	D	23	B	6.03	80	70	103	
16	D	10	T	6.07	82	74	117	
17	D	1	T	6.03	91	87	110	
18	E	18	T	6.45	95	91	115	Wears tip in canal
19	E	6	T	6.55	85	81	108	
20	E	1	B/T	6.22	89	84	119	
21	E	13	T	6.29	96	93	120	
22	E	24	B	6.54	91			Time history
23	E	22	T	6.42	85			Time history; wears tip in canal
24	E	2	B/J	7.08	76	70	100	
25	E	13	T	6.27	102	97	122	
26	E	21	T	7.01	86	80	104	
27	E	6	T	6.58	90	85	113	
28	E	24	B	6.51	94	78		Time history; 4 receivers; 2 phones
29	E	3	T	6.58	94	71		
30	M	1	T	7.42	86	78	118	
31	M	11	T	7.32	80	71	96	
32	M	18	T	7.41	90	86	123	
33	M	6	T	7.29	90			Time history
34	M	2	T	7.39	82			Time history
35	M	6	T	7.41	82	76	109	
36	M	24	B	7.45	99	90	120	Phones off 1 h while copying
37	M	1	T	7.48	83	78	107	
38	M	11	J	7.39	87			Time history; subject took off dosimeter for chow
39	M	25	B	7.34	77			Time history; no activity at position; (earphone hung up with mike on phone)

1. D = day, E = eve, M = mid.
2. B = Bakelite, T = Telex, J = Japanese.
3. Overall equivalent level (3 dB exchange ratio) computed for the entire sample time.
4. Weighted (dBA) equivalent level (5 dB exchange ratio) computed for the entire sample time with all measures below 85 dBA excluded from the calculation.

Table 2. Noise-exposure Distribution by Work Shift.

Work shift	# Sample periods	% Periods LEQ 85 dB or more
Day	17	65
Eve	12	92
Mid	10	50

Table 3. Average Octave Band, dBC and dBA Noise-level Measurements (dB) Taken at Each End of the Operator Area of the Collection Room.

	Octave band center frequency (Hz)											
Position	31.5	63	125	250	500	1000	2000	4000	8000	16000	dBC	dBA
1	68	70	71	69	69	65	63	63	60	54	76	71
2	70	72	72	71	70	67	62	58	58	52	77	72

HEARING

Average high-frequency HTLs of the 25 manual Morse code operators are listed by the operator's length of service (LOS) in Table 4. Brackets indicate a significant high-frequency hearing loss, which is defined as an average hearing decrement of 30 dB or greater at 3000, 4000, and 6000 Hz. Generally, noise does not produce a unilateral hearing loss, but considering that we examined earphone listening (as opposed to a noise field situation) and considering individual preferences in type of and manner of wearing earphones, the significant losses by subjects 1 and 15 could very well be noise-induced. If the unilateral losses are included, 20% of the subjects examined have a significant high-frequency hearing loss. Though not listed in Table 4, 40% of the subjects had at least one frequency in the 3000-6000 Hz range yielding a threshold of 30 dB or greater. Twenty-five subjects represent a small sample and no confident conclusions can be drawn. To afford some perspective to the 20% figure mentioned earlier, a comparison can be offered to hearing data collected earlier on various Navy enlisted ratings (1). In this comparison, the 20% CTR figure would fall between the Aviation Ordnance rate (18%) and the Aviation Mechanics rate (22%), which are both recognized as noise hazardous.

Table 4. Average High-frequency HTLs[a] of 25 Manual Morse Code Operators by Length of Service (LOS).[b]

Subject	LOS (years/months)	Ear Right	Ear Left
1	15/0	[55]	27
2	14/0	12	23
3	12/0	[37]	[60]
4	10/0	13	23
5	9/0	3	8
6	8/0	[57]	[55]
7	6/0	13	20
8	5/6	[45]	[57]
9	5/0	8	10
10	4/0	13	8
11	3/9	15	15
12	3/6	13	25
13	3/6	13	20
14	3/4	8	10
15	3/0	17	[43]
16	3/0	3	5
17	3/0	7	12
18	2/6	8	8
19	2/6	18	7
20	2/4	15	7
21	2/0	3	12
22	2/0	10	7
23	2/0	5	20
24	1/4	5	5
25	0/10	10	12

[a] Mean of HTLs at 3000, 4000, and 6000 Hz.
[b] Brackets indicate an average hearing decrement of 30 db or greater at 3000, 4000, and 6000 Hz.

New Transducers

The shoulder-worn speaker system was not well received. The consensus was 1) it could become uncomfortable over time, 2) it radiated too much noise around the wearer, and 3) because the ears were unoccluded, too much interference was created by ambient room noise. Unless some reasonable solution can be found to overcome these significant objections, further development of this type of device should not be pursued.

The 10 operators who wore the bone-conduction unit generally gave favorable comments concerning signal clarity. Some operators perceived less "hash" in the signal. As with the shoulder-worn unit, the operators' ears were unoccluded when wearing the bone-conduction device. Several operators said that ambient noise in the room interfered with their hearing of low-level code. Some operators were bothered by the laterality of the signal, that is, signals were perceived to be heard on the side where the unit was placed. Benefits of the device would include a reduction of noise radiated into the room, and for more difficult-to-hear signals, the potential for utilizing some tactile sensation to supplement the auditory sense. Because the objections raised by the operators to the bone-conduction unit could be solved with relative ease, we feel that further work on a device of this nature should be pursued.

Compressor Amplifier

The trial of the Altec 436B compressor was successful. Senior technicians who listened to the signals commented that they heard the signals very well and did not experience any difficulty with either high- or low-level signals.

Because time constraints permit only gross adjustments of the frequency or radiofrequency gain controls when operators receive a strong signal on the R-390, an automatic level control circuit, such as a volume compressor, appears to be the most viable solution to the signal-peaking problem. The design and testing of such a circuit modification seem justified on the basis of the clear auditory hazard shown to exist for the manual Morse code operators. A plan for its design and testing should directly involve the NSA systems engineer in charge of the Homestead projects. After testing and validation at the Homestead site, the circuit could be incorporated at other existing or projected automated search installations. Direct contact with the systems engineer and one of the members of the NAVSECGRUCOM-sponsored studies at Northwest and Homestead should be arranged as soon as practical.

CONCLUSIONS

1. Manual Morse code operators face a significant probability of exposure to hazardous noise levels.

2. The type of headset used is not a primary factor in the noise exposure of manual Morse code operators.

3. The new automated signal acquisition system will probably increase operator noise exposure.

4. Ambient noise levels do not constitute a significant source of noise exposure for manual Morse code operators.

REFERENCES

1. Department of the Navy, OPNAVINST 5100.23B, Chapter 18, August 1983.

2. Robertson, R.M., Page, J.C., and Williams, C.E., The Prevalence of Hearing Loss Among Selected Navy Enlisted Personnel, NAMRL-1251, Naval Aerospace Medical Research Laboratory, Pensacola, FL, September 1978. (AD A062 832)

Other Related NAMRL Publications*

Thomas, G.B., Williams, C.E., and Hoger, N.W., "Some Non-Auditory Correlates of the Hearing Threshold Levels of an Aviation Noise-exposed Population." Aviation, Space and Environmental Medicine, Vol. 52, pp. 531-536, 1981.

Thomas, G.B. and Williams, C.E., Noise Susceptibility: A Comparison of Two Naval Aviator Populations, NAMRL-1320, Naval Aerospace Medical Research Laboratory, Pensacola, FL, June 1986. (AD A172 222)

*Publications with AD numbers are available from DTIC, Cameron Station, Alexandria, VA 22314. Publications without AD numbers may be requested from the authors, NAMRL, Bldg. 1953, NAS, Pensacola, FL 32508-5700.